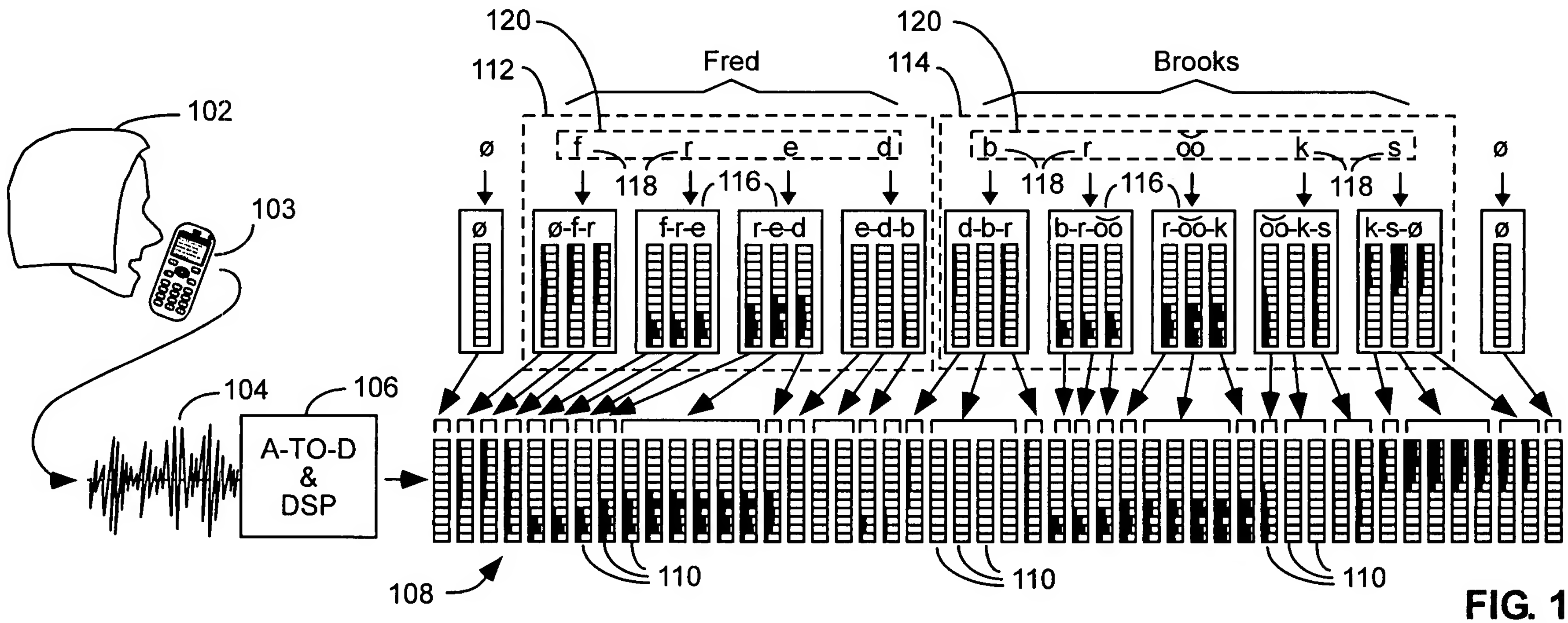


FIG. 1
PRIOR ART

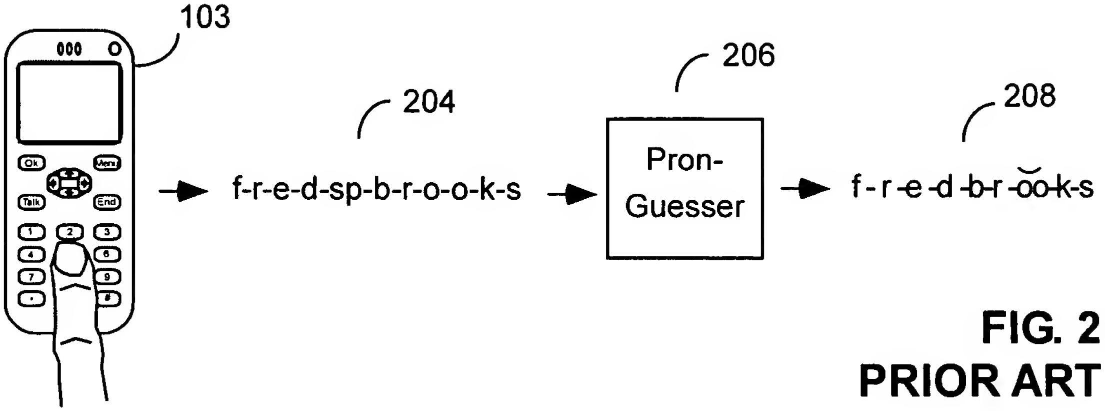


FIG. 2
PRIOR ART

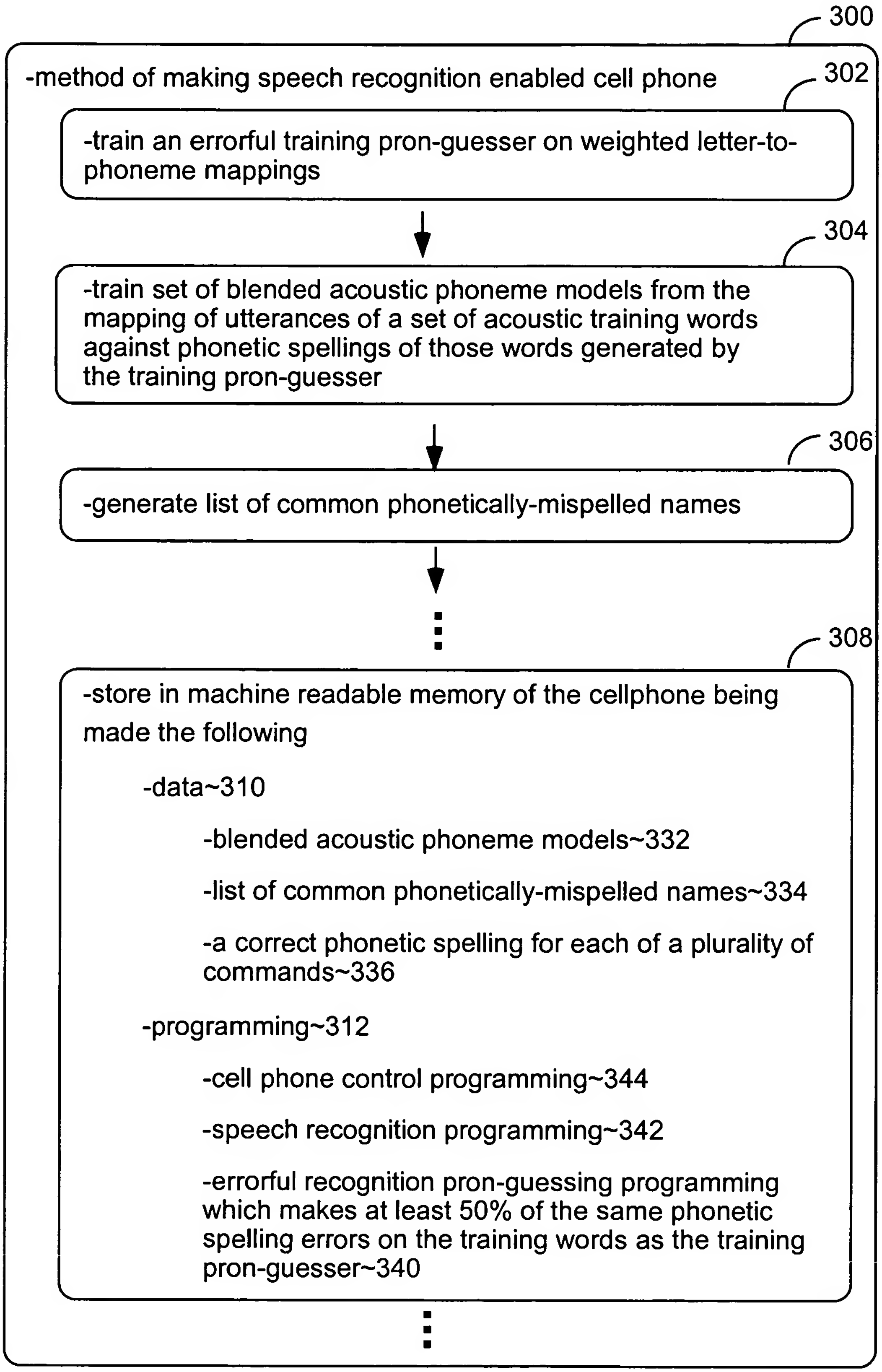
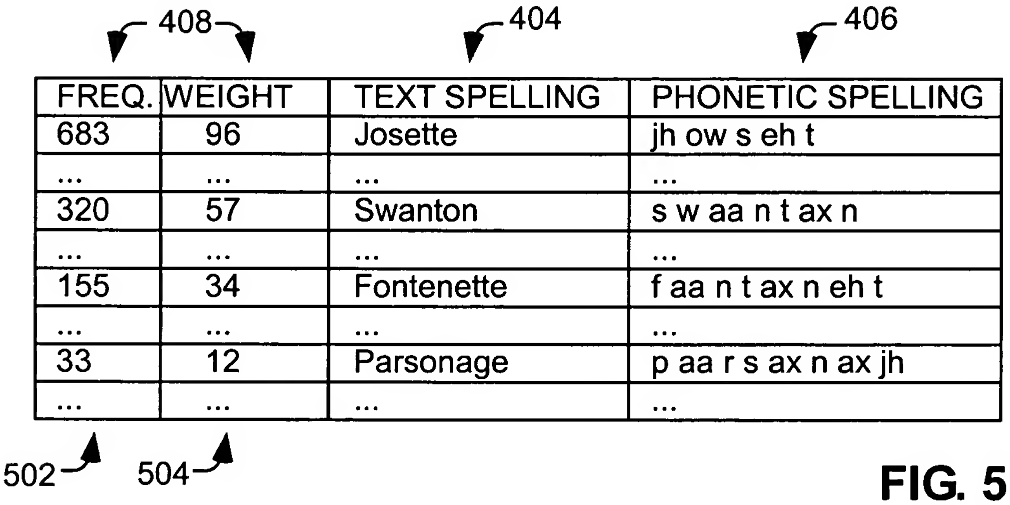

300
-method of making speech recognition enabled cell phone
302
-train an errorful training pron-guesser on weighted letter-to-phoneme mappings
304
-train set of blended acoustic phoneme models from the mapping of utterances of a set of acoustic training words against phonetic spellings of those words generated by the training pron-guesser
306
-generate list of common phonetically-mispelled names
308
-store in machine readable memory of the cellphone being made the following
-data~310
-blended acoustic phoneme models~332
-list of common phonetically-mispelled names~334
-a correct phonetic spelling for each of a plurality of commands~336
-programming~312
-cell phone control programming~344
-speech recognition programming~342
-errorful recognition pron-guessing programming which makes at least 50% of the same phonetic spelling errors on the training words as the training pron-guesser~340

FIG. 3

```
-Training pron-guesser~302
    -for each of a set of pron-guesser training words, obtaining ~402
        -a textual spelling for the word~404
        -a phonetic spelling for the word~406
        -frequency with which the word occurs~408
    -for each training word~410
        -map letters of word's textual spelling against phonemes of the phonetic spelling for the word~412
        -for each letter in the word~414
            -create an associated letter context that contains~416
                -the letter~418
                -the phoneme it is mapped to in the word~420
                -the context of letters, if any, that occur near the letter in the word~422
                -a frequency weight calculated as a function of the frequency of the word raised to a power less than one~424
    -bin together all occurrences of identical letter contexts from all the trainging words~426
    -for each set of identical letter contexts~428
        -create a summed frequency weight equal to the sum of all the frequency weights from all letter context in set~430
    -for each letter~432
        -call a pronGuesserDTreeTraining for the set of letter contexts created for the letter, with its summed frequency weight~434
```

FIG. 4



FREQ.	WEIGHT	TEXT SPELLING	PHONETIC SPELLING
683	96	Josette	jh ow s eh t
...	...	...	...
320	57	Swanton	s w aa n t ax n
...	...	...	...
155	34	Fontenette	f aa n t ax n eh t
...	...	...	...
33	12	Parsonage	p aa r s ax n ax jh
...	...	...	...

408
404
406
502
504

FIG. 5

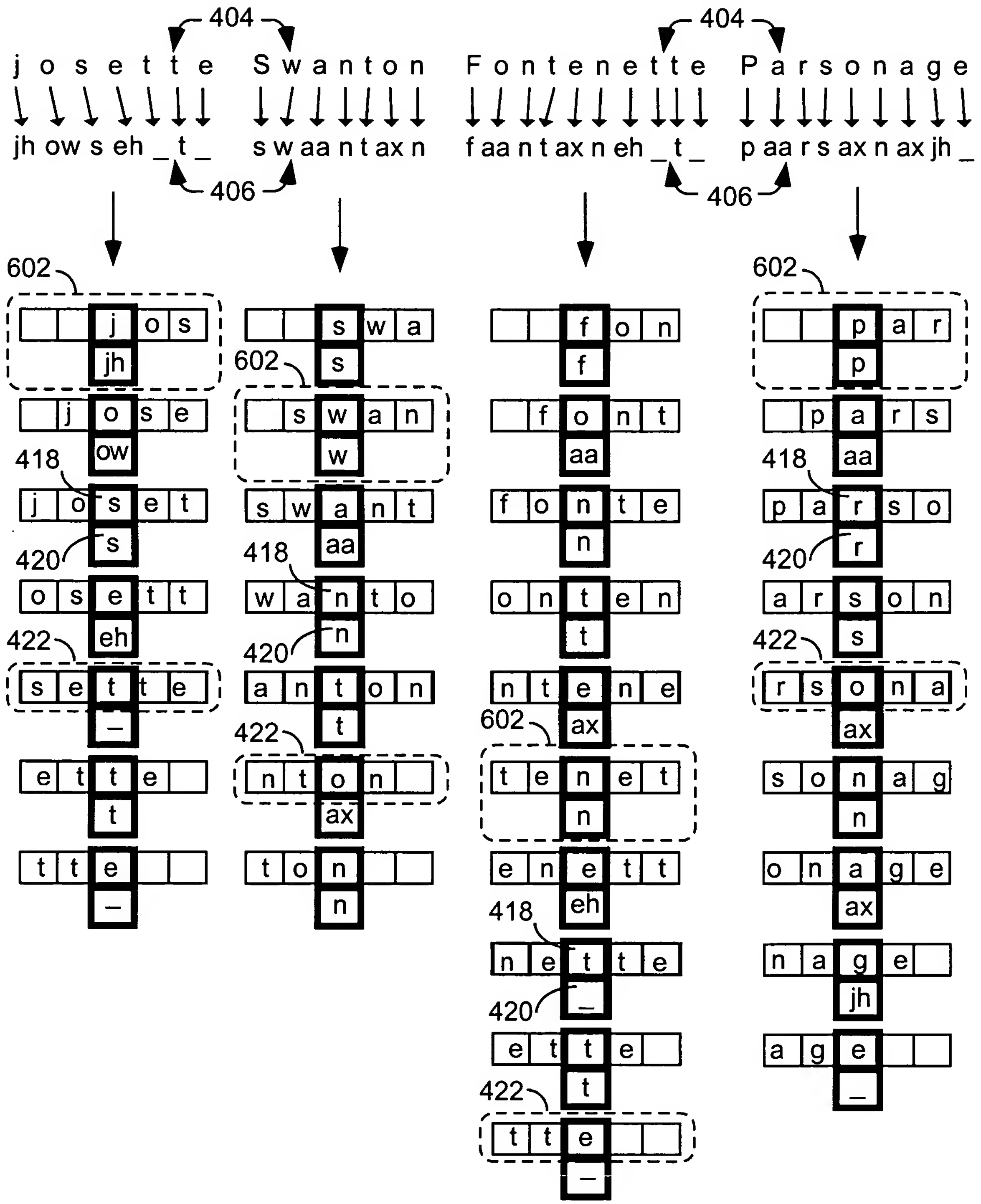

404
404
josette
Swanton
Fontenette
Parsonage
jh ow s eh _ t _
s w aa n t ax n
f aa n t ax n eh _ t _
p aa r s ax n ax jh _
406
406
602
602
602
602
418
418
418
418
420
420
420
420
422
422
422
422

FIG. 6

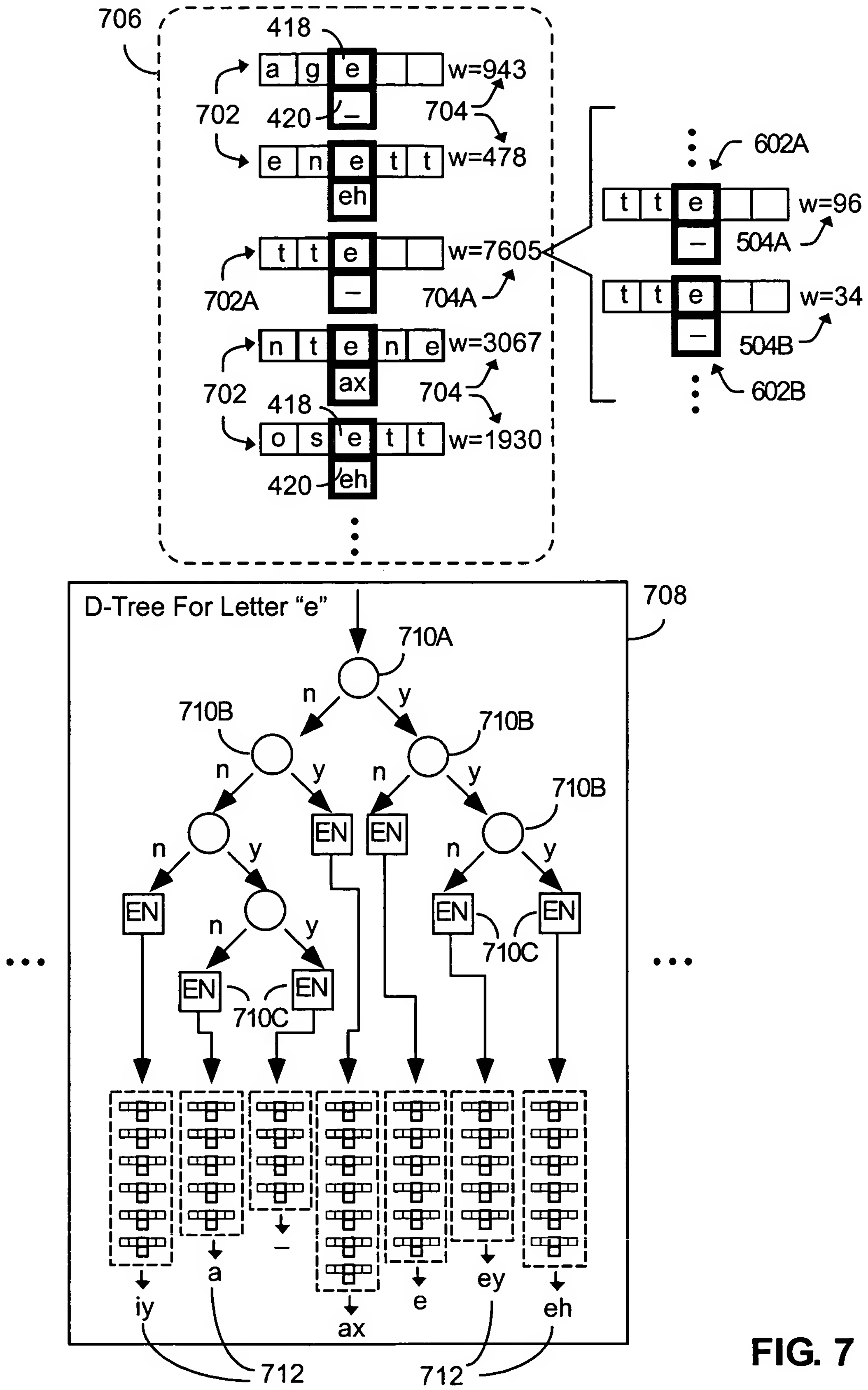

706
418
a g e
w=943
702
420
–
704
e n e t t
w=478
eh
t t e
w=7605
–
702A
704A
n t e n e
w=3067
ax
702
704
418
o s e t t
w=1930
420
eh
602A
t t e
w=96
–
504A
t t e
w=34
–
504B
602B
D-Tree For Letter "e"
708
710A
n
y
710B
710B
n
y
n
y
710B
EN
EN
n
y
n
y
EN
EN
EN
n
y
710C
EN
EN
710C
iy
a
–
ax
e
ey
eh
712
712

FIG. 7

```
-pronGuesserDTreeTraining~800
    -call processD-TreeNode with~802
        -currentNode equal to the d-tree's root node~804
        -currentContextSet equal to the set of contexts supplied to the d-tree's root~806
```

FIG. 8

```
-processDTreeNode (currentContextSet, currentNode)~900
    -for each possible context question~902
        -divide the current context set into two new context sets, one of contexts that satisfy the question and one of contexts that do not~904
        -for each of the two new context sets~906
            -calculate the entropy of the context set based on the distribution phonemes associated with the contexts of the set, weighting the contribution of each context's phoneme to the distribution as a function of the context's associated frequency based weight~900
        -if this total entropy for the two new context sets is the lowest calculated so far for the current node~908
            -save the entropy value as minEntropy~910
            -save the current context question as bestQuestion~912
            -save the two new context sets~914
    -if the difference between the entropy of the currentContextSet and minEntropy is not greater than a given amount~916
        -make the new node a terminal node~918
        -set the outputPhoneme for the terminal node equal to the phoneme associated with the largest number contexts in the node's context set~920
    -else~921
        -created a new node for each of the two new context sets~922
        -for each of two new nodes~924
            -if the number of contexts in the new node's context set is above a given number~926
                -call processDTreeNode with~928
                    -currentNode equal to new node~930
                    -currentContextSet equal to the new node's context set~932
            -else~934
                -make the new node a terminal node~936
                -set the outputPhoneme for the terminal node equal to the phoneme associated with the largest number contexts in the node's context set~938
```

FIG. 9

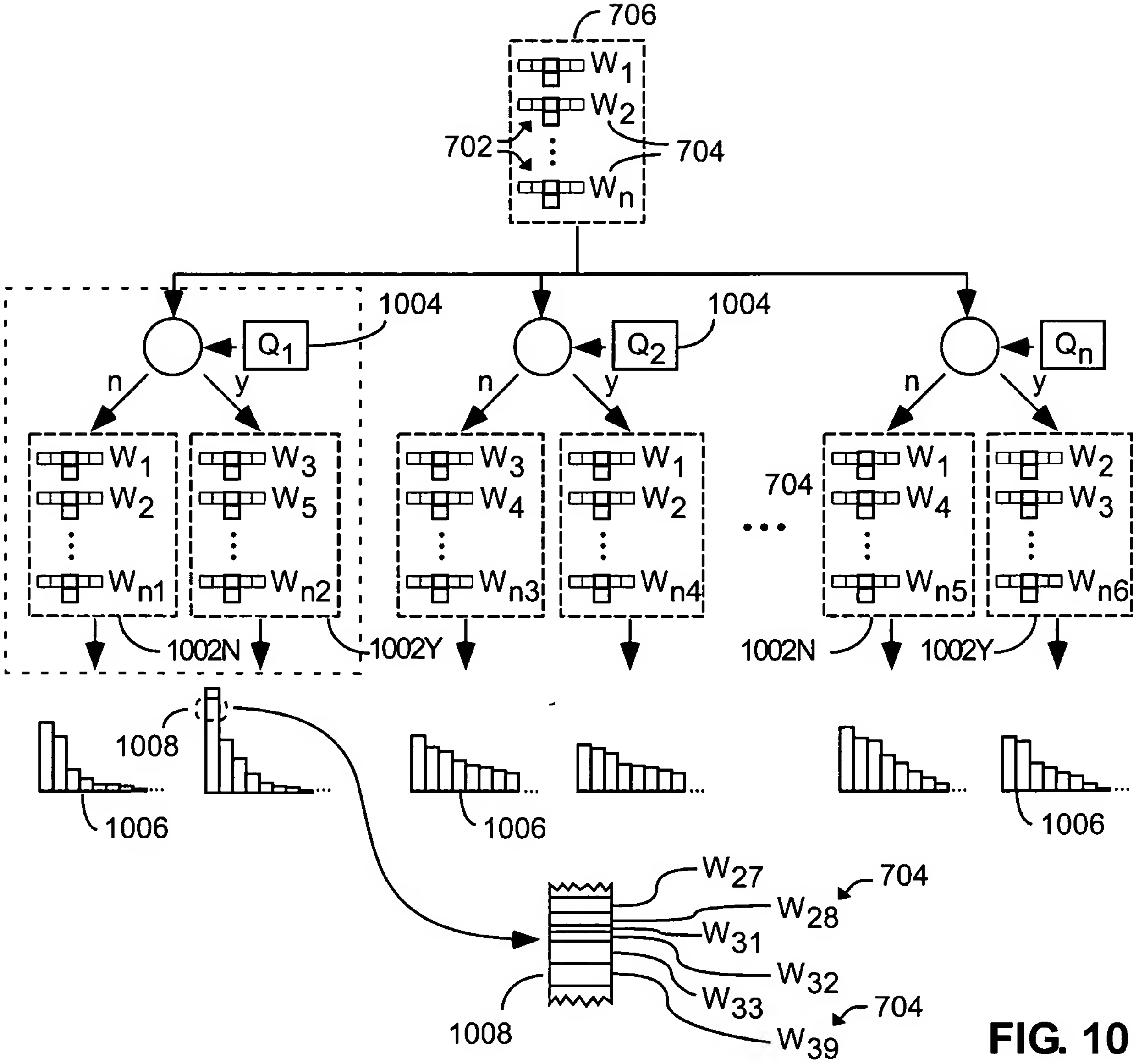

706
W1
W2
702
704
Wn
1004
Q1
1004
Q2
Qn
n
y
n
y
n
y
W1
W2
Wn1
W3
W5
Wn2
W3
W4
Wn3
W1
W2
Wn4
704
W1
W4
Wn5
W2
W3
Wn6
1002N
1002Y
1002N
1002Y
1008
1006
1006
1006
W27
W28
704
W31
W32
W33
704
W39
1008

FIG. 10

```
-pron-guessing programming~1100
    -for each successive letter in the spelling of the word for which phonetic
    spelling is to be produced~1106
        -create a mapping context of the type used in training the pron-guesser's
        d-trees for the letter~1108
        -send the letter context through the d-tree corresponding to the given
        letter~1110
        -add the output phoneme associated with the end node of the d-tree into
        which the letter context is mapped to the phonetic spelling being created
        for the name~1112
```

FIG. 11

Correct pronunciations:

Cheryl	sh eh r ax l
Igor	iy g ao r
Jose	hh ow z ey
Philippe	f ih l iy p
Rene	r ax n ey

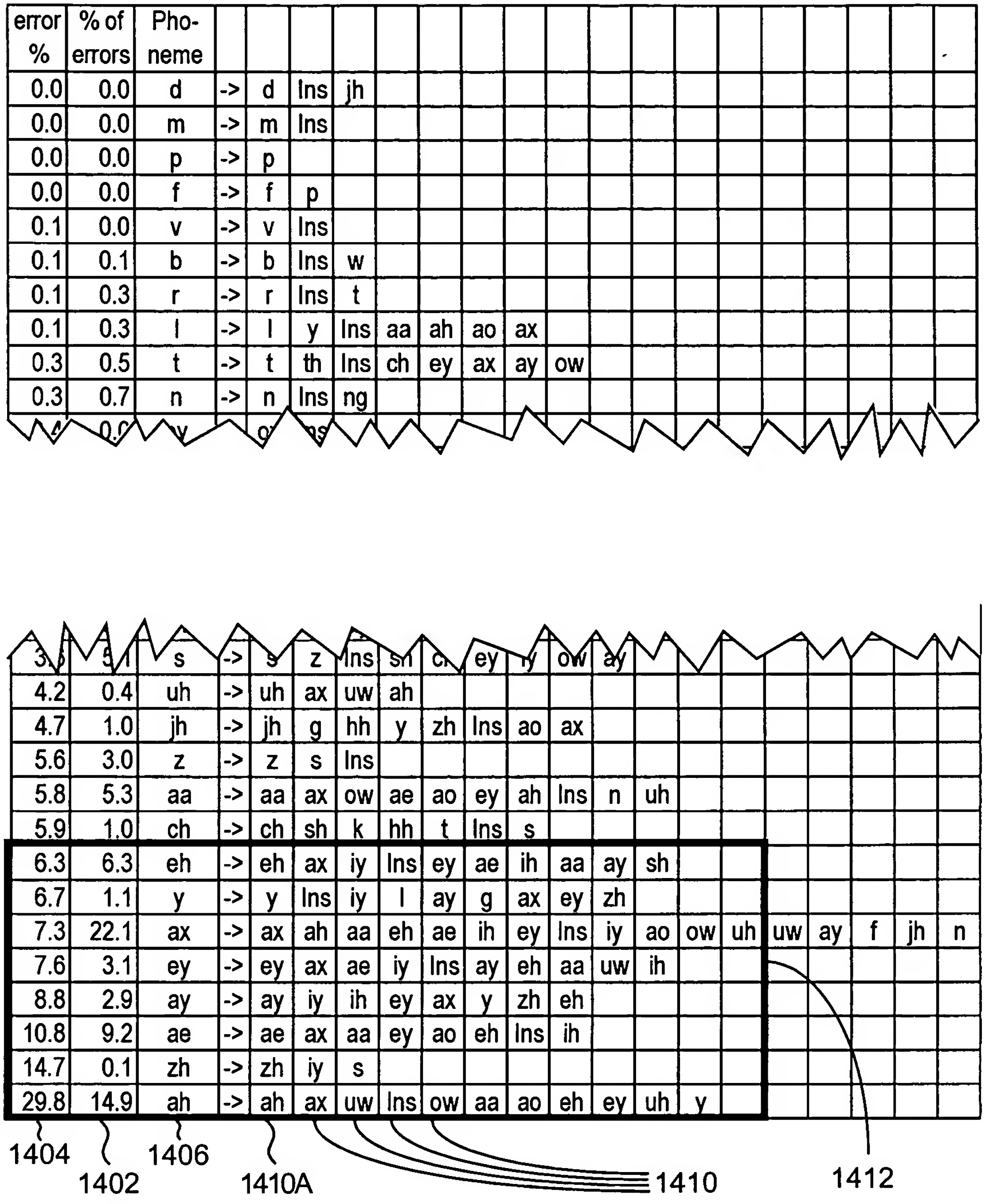
Incorrect guessed pronunciations:

Cheryl	ch eh r ax l	(starts with “ch” sound instead of “sh”)
Igor	iy g ax r	(pronounced as “eager”)
Jose	jh ow z ey	(starts with “j” sound instead of “h”)
Philippe	f ih l ih p	(pronounced as “Philip”)
Rene	r ax n	(final “e” is dropped)

FIG. 12

aa	sound of “o”	in “pot”
ae	sound of “a”	in “at”
ah	sound of “u”	in “but”
ax	sound of “a”	in “about” (schwa)
ay	sound of “i”	in “night”
b	sound of “b”	in “boy”
ch	sound of “ch”	in “children”
d	sound of “d”	in “day”
eh	sound of “e”	in “bet”
ey	sound of “a”	in “fake”
f	sound of “f”	in “food”
hh	sound of “h”	in “hey”
ih	sound of “i”	in “bit”
iy	sound of “ee”	in “bee”
jh	sound of “j”	in “judge”
l	sound of “l”	in “light”
m	sound of “m”	in “may”
n	sound of “n”	in “new”
ow	sound of “o”	in “no”
p	sound of “p”	in “pay”
r	sound of “r”	in “ray”
s	sound of “s”	in “so”
sh	sound of “sh”	in “shame”
t	sound of “t”	in “time”
uh	sound of “oo”	in “hood”
v	sound of “v”	in “very”
w	sound of “w”	in “will”
y	sound of “y”	in “yes”
z	sound of “z”	in “zoo”
zh	sound of “si”	in “Asia”

FIG. 13



error %	% of errors	Pho-neme																		
0.0	0.0	d	->	d	Ins	jh														
0.0	0.0	m	->	m	Ins															
0.0	0.0	p	->	p																
0.0	0.0	f	->	f	p															
0.1	0.0	v	->	v	Ins															
0.1	0.1	b	->	b	Ins	w														
0.1	0.3	r	->	r	Ins	t														
0.1	0.3	l	->	l	y	Ins	aa	ah	ao	ax										
0.3	0.5	t	->	t	th	Ins	ch	ey	ax	ay	ow									
0.3	0.7	n	->	n	Ins	ng														
0.4	0.0	y		[illegible]	Ins															
3.5	5.1	s	->	s	z	Ins	sh	ch	ey	iy	ow	ay								
4.2	0.4	uh	->	uh	ax	uw	ah													
4.7	1.0	jh	->	jh	g	hh	y	zh	Ins	ao	ax									
5.6	3.0	z	->	z	s	Ins														
5.8	5.3	aa	->	aa	ax	ow	ae	ao	ey	ah	Ins	n	uh							
5.9	1.0	ch	->	ch	sh	k	hh	t	Ins	s										
6.3	6.3	eh	->	eh	ax	iy	Ins	ey	ae	ih	aa	ay	sh							
6.7	1.1	y	->	y	Ins	iy	l	ay	g	ax	ey	zh								
7.3	22.1	ax	->	ax	ah	aa	eh	ae	ih	ey	Ins	iy	ao	ow	uh	uw	ay	f	jh	n
7.6	3.1	ey	->	ey	ax	ae	iy	Ins	ay	eh	aa	uw	ih							
8.8	2.9	ay	->	ay	iy	ih	ey	ax	y	zh	eh									
10.8	9.2	ae	->	ae	ax	aa	ey	ao	eh	Ins	ih									
14.7	0.1	zh	->	zh	iy	s														
29.8	14.9	ah	->	ah	ax	uw	Ins	ow	aa	ao	eh	ey	uh	y						

FIG. 14

	error %	% of errors	Pho-neme													
1502~	6.3	6.3	eh	->	eh	ax	iy	Ins	ey	ae	ih	aa	ay	sh		
1504~			5794	->	5430	201	86	26	17	13	13	6	1	1		
1506~			100.00%	->	93.72%	3.47%	1.48%	0.45%	0.29%	0.22%	0.22%	0.10%	0.02%	0.02%		
	6.7	1.1	y	->	y	Ins	iy	l	ay	g	ax	ey	zh			
			969	->	904	42	7	5	4	4	1	1	1			
			100.00%	->	93.29%	4.33%	0.72%	0.52%	0.41%	0.41%	0.10%	0.10%	0.10%			
1501	7.3	22.1	ax	->	ax	ah	aa	eh	ae	ih	ey	Ins	iy	ao	ow	uh
			17460	->	16188	272	218	206	184	155	90	66	24	17	17	9
			100.00%	->	92.71%	1.56%	1.25%	1.18%	1.05%	0.89%	0.52%	0.38%	0.14%	0.10%	0.10%	0.05%
	7.6	3.1	ey	->	ey	ax	ae	iy	Ins	ay	eh	aa	uw	ih		
			2359	->	2181	61	60	17	11	9	9	8	2	1		
			100.00%	->	92.45%	2.59%	2.54%	0.72%	0.47%	0.38%	0.38%	0.34%	0.08%	0.04%		
1502~	8.8	2.9	ay	->	ay	iy	ih	ey	ax	y	zh	eh				
1504~			1894	->	1727	83	72	5	2	2	2	1				
1506~			100.00%	->	91.18%	4.38%	3.80%	0.26%	0.11%	0.11%	0.11%	0.05%				
	10.8	9.2	ae	->	ae	ax	aa	ey	ao	eh	Ins	ih				
			4912	->	4381	317	84	60	51	12	6	1				
			100.00%	->	89.19%	6.45%	1.71%	1.22%	1.04%	0.24%	0.12%	0.02%				
1501	14.7	0.1	zh	->	zh	iy	s									
			34	->	29	4	1									
			100.00%	->	85.29%	11.76%	2.94%									
	29.8	14.9	ah	->	ah	ax	uw	Ins	ow	aa	ao	eh	ey	uh	y	
			2876	->	2018	810	29	8	3	2	2	1	1	1	1	
			100.00%	->	70.17%	28.16%	1.01%	0.28%	0.10%	0.07%	0.07%	0.03%	0.03%	0.03%	0.03%	
	1404	1406	1402		1410A		1410					1410				

FIG. 15

```
-training blended acoustic phoneme models~1600
    -for each of a plurality of acoustic training words~dd02
        -have errorful pron-guessing programming generate a phonetic spelling for word~dd04
        -create an untrained associate word model for the word, composed of a sequence of untrained acoustic phoneme models corresponding to the word's phonetic spelling~dd06
    -repeatedly~dd08
        -use HMM to map one or more utterances of each training word against the acoustic model for that word~dd10
        -alter each acoustic phoneme model to be more like the utterance sounds mapped against it in all training words in which it occurs~dd12
    -for each phoneme~dd14
        -for each node number n = 1 through 3~dd16
            -call acoustic node clustering d-tree algorithm for the nth node of the set of all triphone model for the given phoneme~dd18
```

FIG. 16

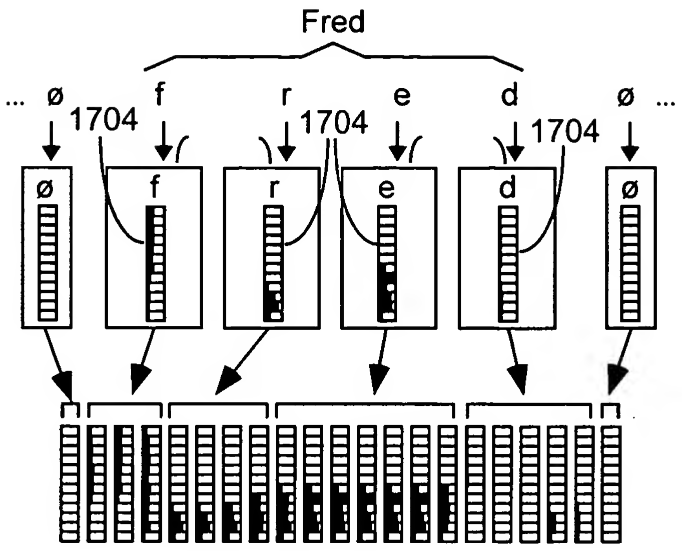


FIG. 17

1704

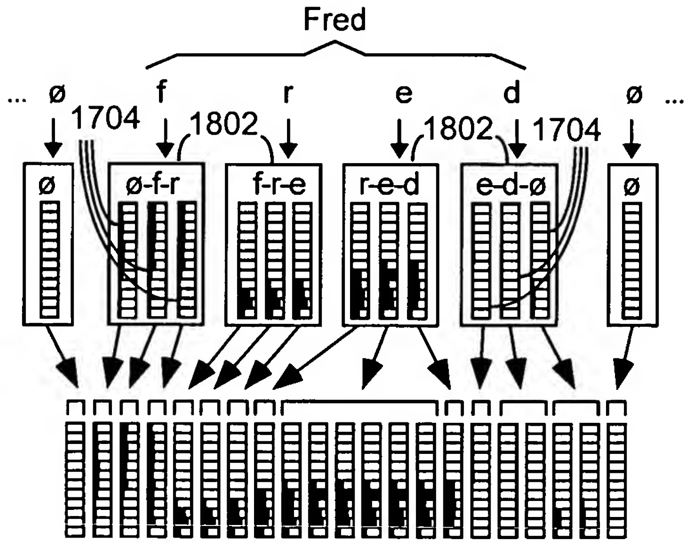


FIG. 18

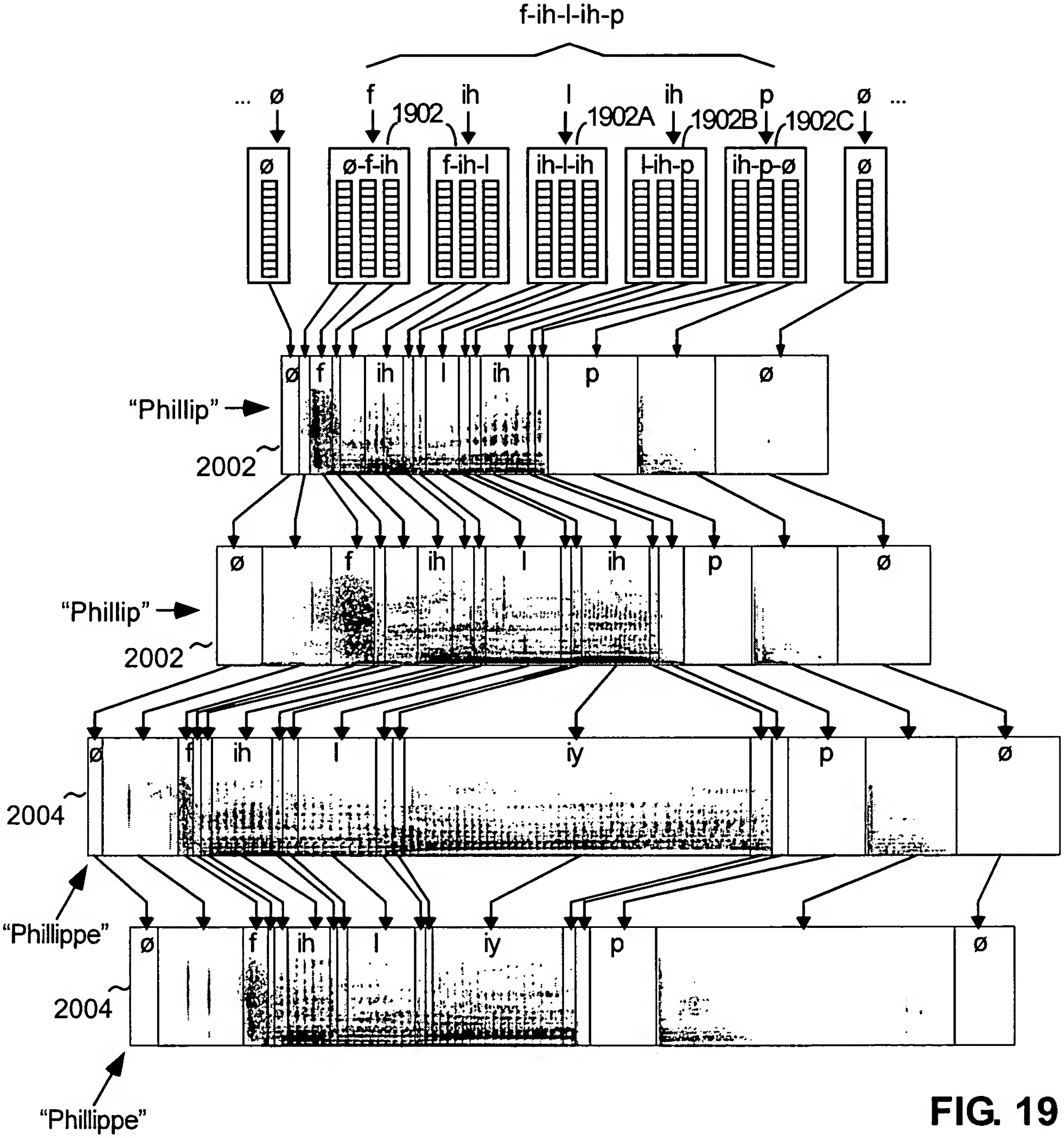

f-ih-l-ih-p
... ø
f
ih
l
ih
p
ø ...
1902
1902A
1902B
1902C
ø
ø-f-ih
f-ih-l
ih-l-ih
l-ih-p
ih-p-ø
ø
"Phillip"
2002
ø
f
ih
l
ih
p
ø
"Phillip"
2002
ø
f
ih
l
ih
p
ø
2004
ø
f
ih
l
iy
p
ø
"Phillippe"
2004
ø
f
ih
l
iy
p
ø
"Phillippe"

FIG. 19

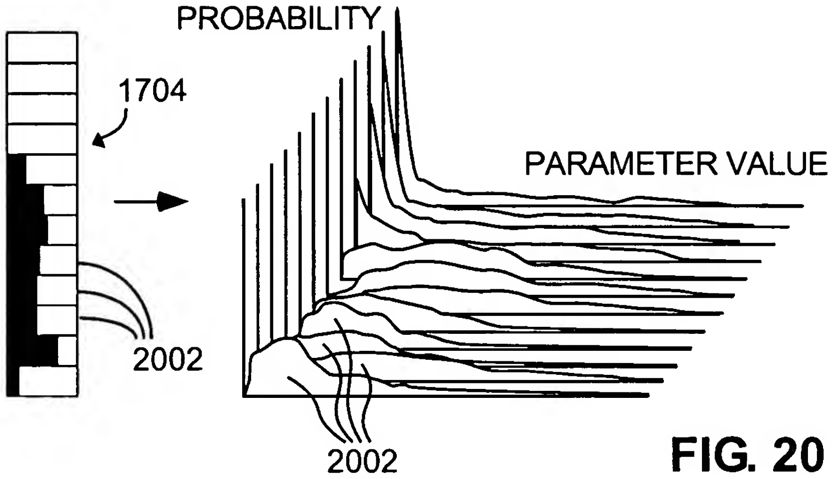


FIG. 20

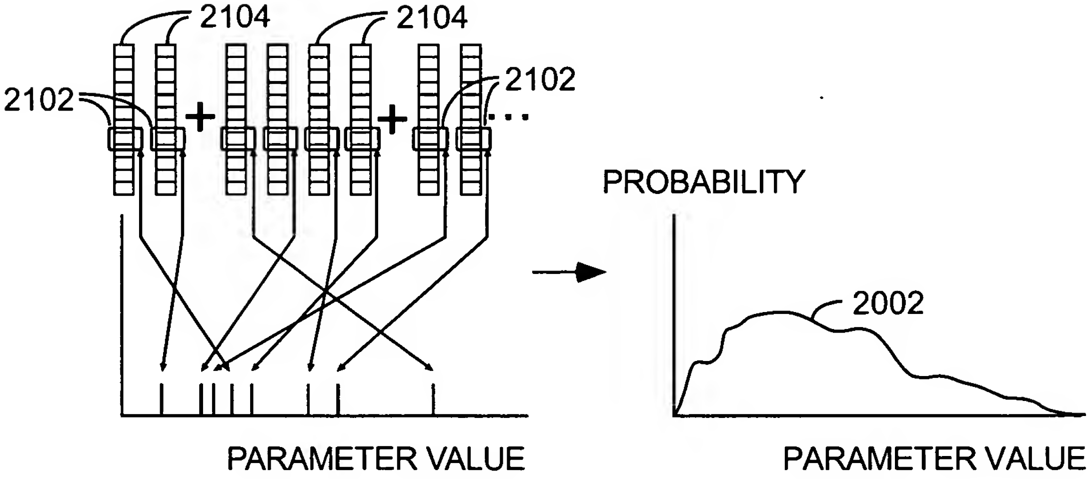


FIG. 21

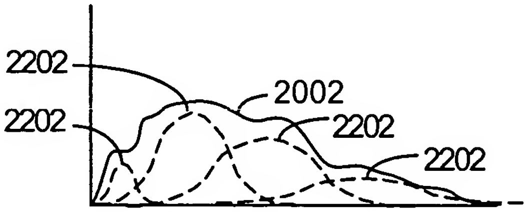


FIG. 22

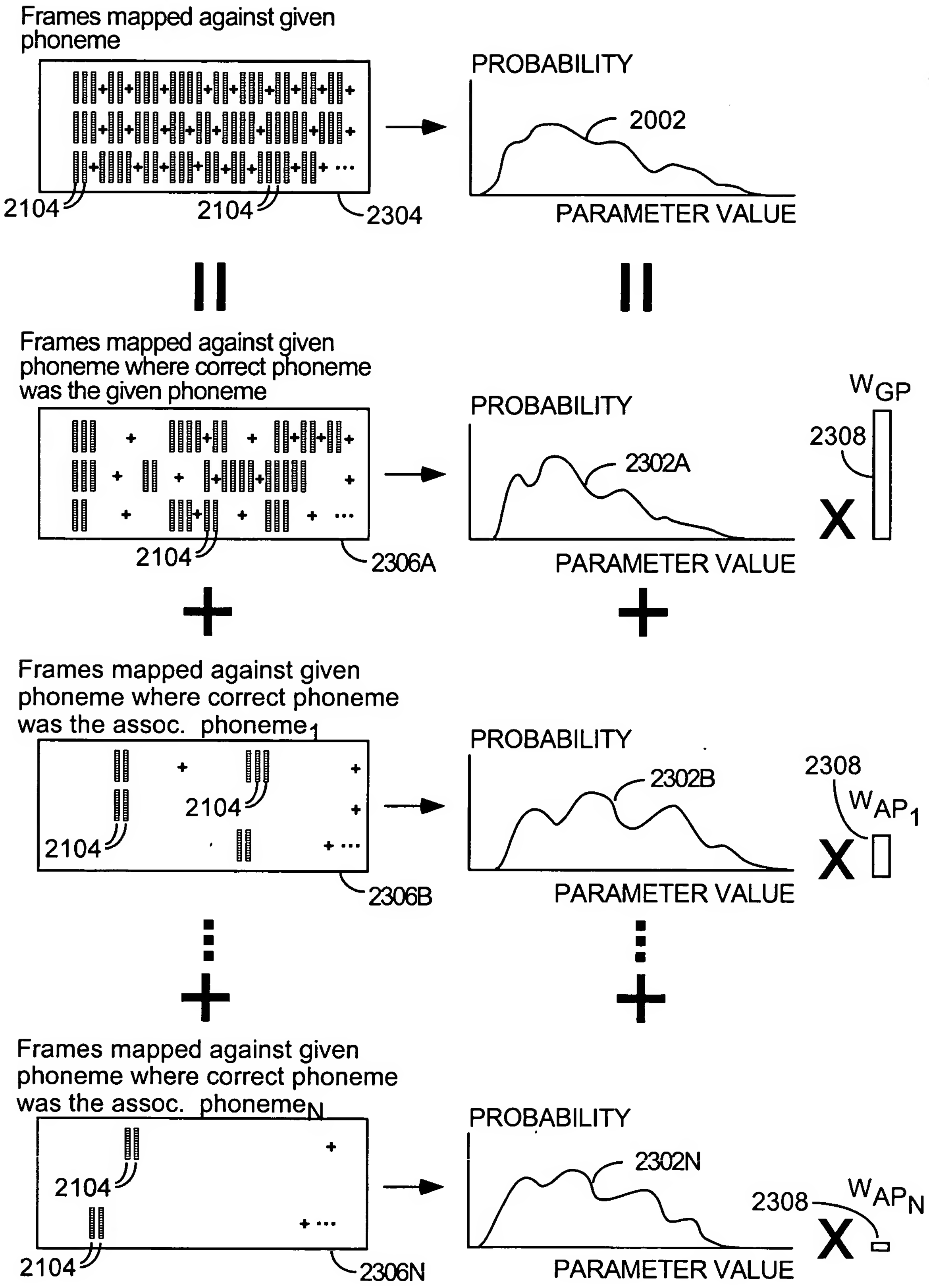

Frames mapped against given phoneme
2104
2104
2304
PROBABILITY
2002
PARAMETER VALUE
Frames mapped against given phoneme where correct phoneme was the given phoneme
2104
2306A
PROBABILITY
2302A
PARAMETER VALUE
W_GP
2308
X
Frames mapped against given phoneme where correct phoneme was the assoc. phoneme_1
2104
2104
2306B
PROBABILITY
2302B
PARAMETER VALUE
2308
W_AP1
X
Frames mapped against given phoneme where correct phoneme was the assoc. phoneme_N
2104
2104
2306N
PROBABILITY
2302N
PARAMETER VALUE
2308
W_APN
X

FIG. 23

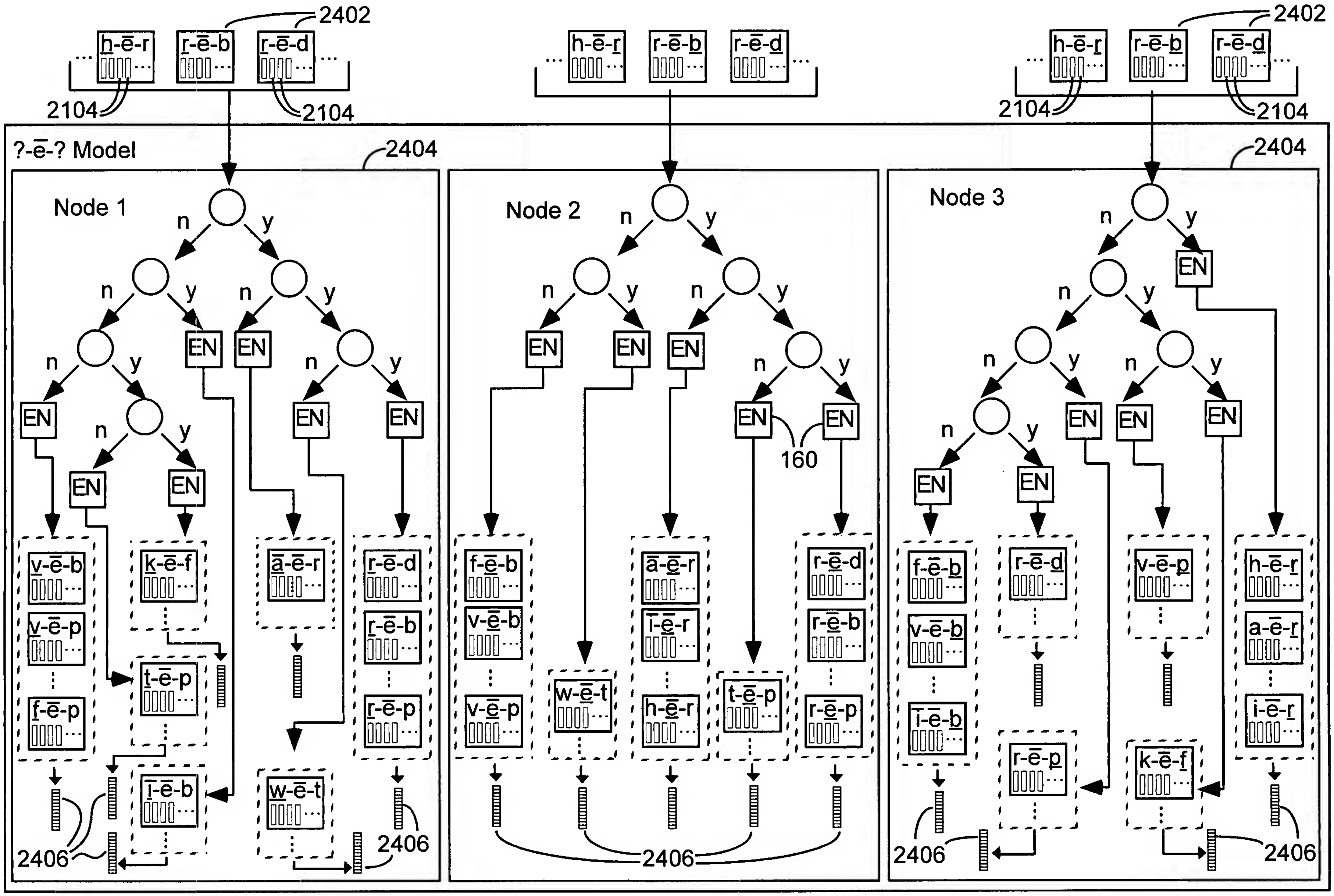

2402
2104
2104
?-ē-? Model
2404
Node 1
Node 2
Node 3
h-ē-r
r-ē-b
r-ē-d
n
y
EN
160
v-ē-b
v-ē-p
f-ē-p
k-ē-f
t-ē-p
ī-ē-b
ā-ē-r
w-ē-t
r-ē-d
r-ē-b
r-ē-p
f-ē-b
v-ē-b
v-ē-p
ā-ē-r
ī-ē-r
h-ē-r
t-ē-p
r-ē-d
r-ē-b
r-ē-p
f-ē-b
v-ē-b
ī-ē-b
r-ē-d
r-ē-p
v-ē-p
k-ē-f
h-ē-r
a-ē-r
i-ē-r
2406

FIG. 24

```
-creating list of common phonetically-mispelled names~306
    -for each of a set of common names~2502
        -compare guessed phonetic spelling produced by recognition pron-guessers with known phonetic spellings for name~2504
        -if the guessed phonetic spelling is wrong, mark word as phonetically misspelled~2506
    -for each of a given number of the most common of the names marked as phonetically misspelled~2508
        -add to the list of common phonetically misspelled names~2510
            -the spelling of the name~2512
            -the correct phonetic spelling of the name~2514
```

FIG. 25

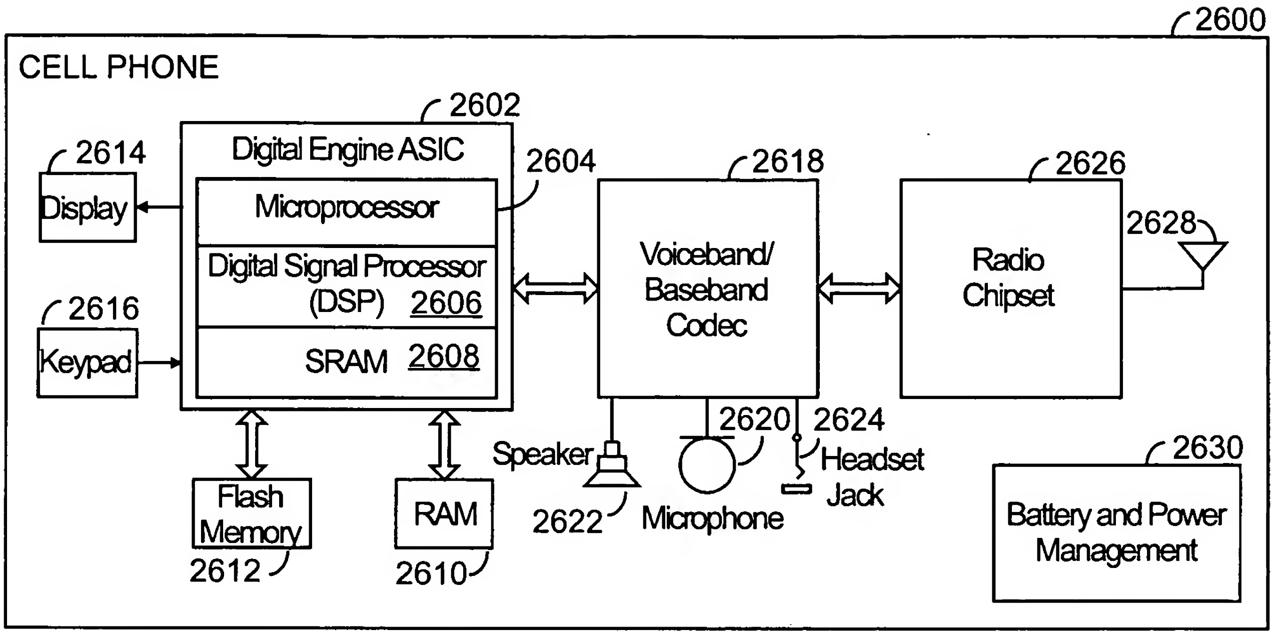

2600
CELL PHONE
2602
Digital Engine ASIC
2614
Display
Microprocessor
2604
2618
2626
Digital Signal Processor (DSP) 2606
Voiceband/ Baseband Codec
Radio Chipset
2628
2616
Keypad
SRAM 2608
2620
2624
Speaker
Headset Jack
2630
Flash Memory
RAM
2622
Microphone
Battery and Power Management
2612
2610

FIG. 26

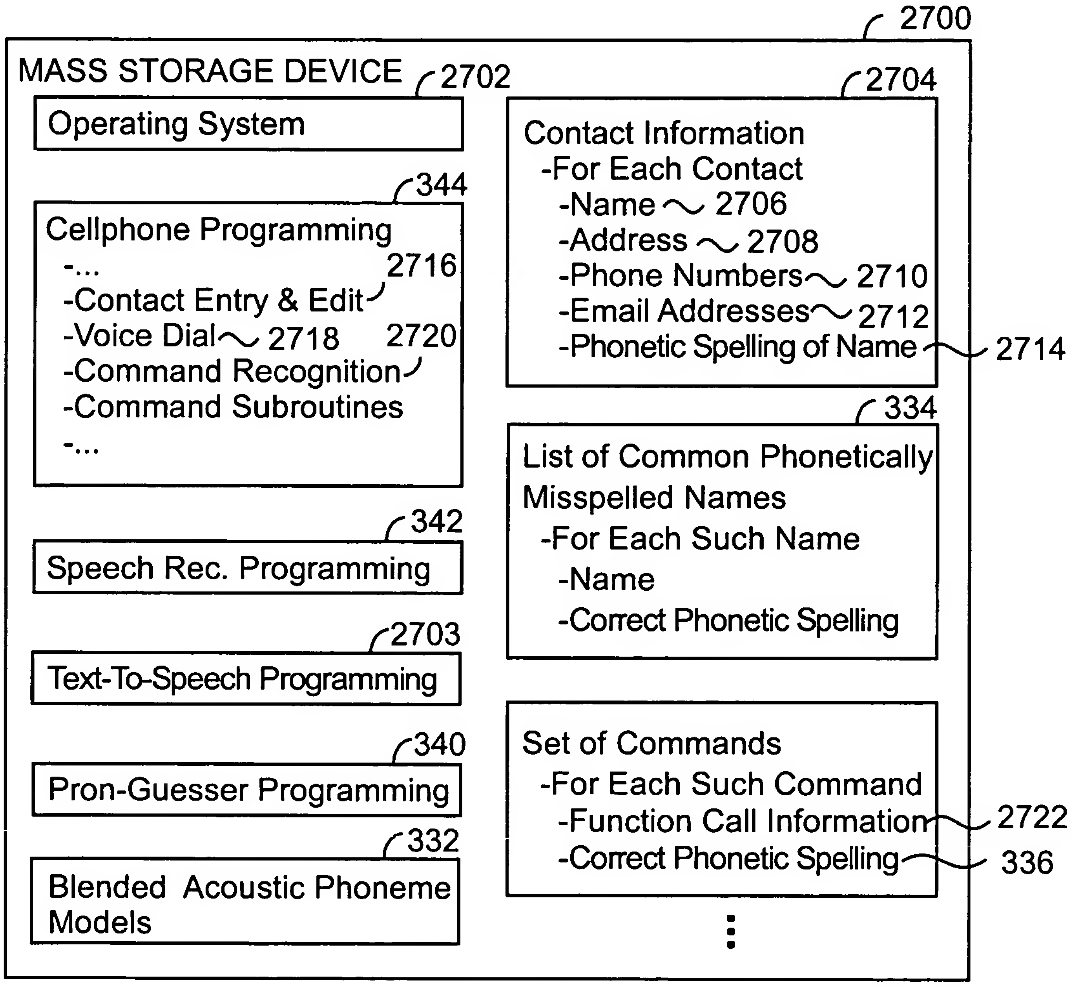

2700
MASS STORAGE DEVICE
2702
Operating System
2704
Contact Information
-For Each Contact
-Name 2706
-Address 2708
-Phone Numbers 2710
-Email Addresses 2712
-Phonetic Spelling of Name 2714
344
Cellphone Programming
-...
2716
-Contact Entry & Edit
-Voice Dial 2718
2720
-Command Recognition
-Command Subroutines
-...
334
List of Common Phonetically Misspelled Names
-For Each Such Name
-Name
-Correct Phonetic Spelling
342
Speech Rec. Programming
2703
Text-To-Speech Programming
340
Pron-Guesser Programming
Set of Commands
-For Each Such Command
-Function Call Information 2722
-Correct Phonetic Spelling 336
332
Blended Acoustic Phoneme Models
⋮

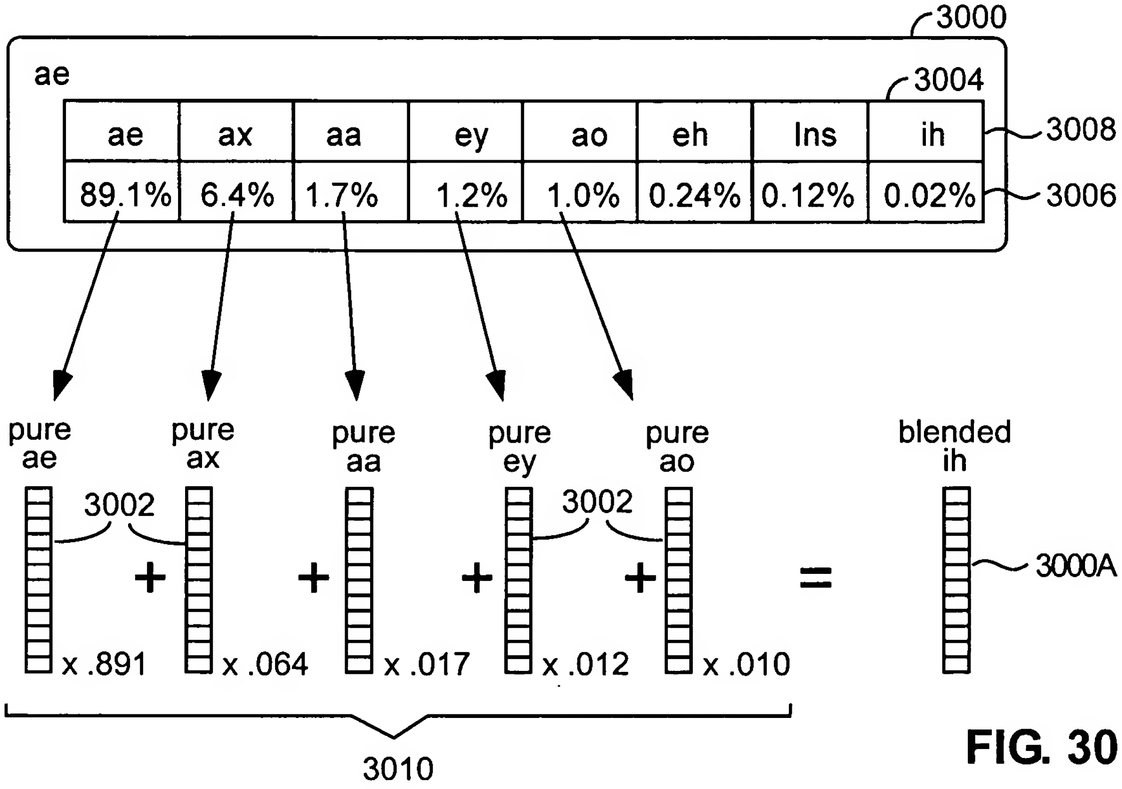
FIG. 27

```
-cell phone control programming~334
    -...
    -if user selects phone contact entry mode~2802
        -call name entry routine to enable user to enter name~2804
        -if user enters a spelling of a name~2806
            -create a blank phone contact record~2808
            -enter spelling of name in name field of record~2810
            -if spelling is one for which a correct phonetic spelling has
            been stored~2812
                -place correct phonetic spelling in phonetic spelling field of
                record~2814
            -else~2815                                                        2716
                -call pron-guesser for name~2816
                -place phonetic spelling generated by pron-guesser in
                phonetic spelling field for record~2818
            -call phone number entry routine to enable user to enter
            phone number~2820
            -...
            -if user enters a phone number~2822
                -place entered phone number in phone number field of
                record~2824
            -...
        -...
    -...
    -if user selects voice dial~2826
        -call the speech recognition programming with a vocabulary
        corresponding the names and corresponding phonetic spellings,
        whether guess or known correct, in the contact records and one or
        more command words and their known correct spellings~2828
        -if best match is a name in a contact record~2830                    2718
            -if there is a phone number stored in the contact record~2832
                -use text-to-speech synthesizer to generate sound of
                recognized name using its phonetic spelling~2833
                -dial that number~2834
        -else if best match is a command~2836
            -call subroutine associated with the given command~2838
    -...
    -if in command recognition mode~2840
        -call the speech recognition programming with a vocabulary
        corresponding to the commands recognizable in the command
        mode~2842                                                             2720
        -if best match is a given command~2844
            -call subroutine associated with the given command~2846
```

FIG. 28

```
-speech recognition programming~342
    -if detect an utterance~2902
        -score the match between sounds of the utterance and the sequence of blended acoustic phoneme models corresponding with the phonetic spelling of each word in the vocabulary for which the recognition program has been called~2906
        -return with an indication of one or more words having the best score in the match~2908
```

FIG. 29



ae

ae	ax	aa	ey	ao	eh	Ins	ih
89.1%	6.4%	1.7%	1.2%	1.0%	0.24%	0.12%	0.02%

FIG. 30

```
-training pure acoustic phoneme models~1600A
    -for each of a plurality of acoustic training words~1602
        -OBTAIN A CORRECT PHONETIC SPELLING FOR THE WORD~1604A
        -create an untrained associate word model for the word, composed of a sequence of untrained acoustic phoneme models corresponding to the word's phonetic spelling~1606
    -repeatedly~1608
        -use HMM to map one or more utterances of each training word against the acoustic model for that word~1610
        -alter each acoustic phoneme model to be more like the utterance sounds mapped against it in all training words in which it occurs~1612
```

FIG. 31

```
-training segregated blended models~3200
    -for each phoneme~3202
        -create an empty mapping list for the phoneme~3204
    -for each of a plurality of acoustic training words~3206
        -have pron-guesser guess phonetic spelling for the word~3208
        -map phonemes of guessed phonetic spelling for word against correct phonetic spelling for word~3210
        -for each guessed phoneme in guessed phonetic spelling~3212
            -find the sequence of one or more correct phonemes mapped against the guessed phoneme~3214
            -if the sequence mapped against the guessed phoneme does not already have an entry in the guessed phoneme's mapping list~3216
                -create an entry in that mapping list for the sequence of one or more correct phonemes and set its count to one~3218
            -else~3220
                -increment the count of the entry in the guessed phoneme's mapping list corresponding to the sequence of one or more correct phonemes~3222
    -for each phoneme~3224
        -normalize the count of its mapping list, so that the total of the count associated with all phonemes in the list equals one~3226
```

FIG. 32

```
-adapting pure acoustic models~3300
    -prompt user to say utterances of one or more adaptation training words~3302
    -map utterances of each adaptation training word against a sequence of pure acoustic phoneme models corresponding to a correct phonetic spelling of that word~3304
    -use the sounds mapped against each pure acoustic phoneme models to adapt that model~3306
    -for each given phoneme~3308
        -create an empty blended acoustic phoneme model for the given phoneme~3310
        -for each phoneme listed in the given phoneme's mapping list having a count above a certain value~3312
            -multiply the pure model of the listed phoneme by the listed phoneme's count in the mapping list~3314
            -add the resulting product to blended acoustic phoneme model for the given phoneme~3316
```

FIG. 33

```
-speech recognizing against segregated acoustic models~342A
    -if detect an utterance~2902
        -score the match between sounds of the utterance and the sequence of SEGREGATED blended acoustic phoneme models corresponding with the phonetic spelling of each word of the vocabulary for which the recognition program has been called~2906A
        -return with an indication of one or more words having the best score in the match~2908
```

FIG. 34

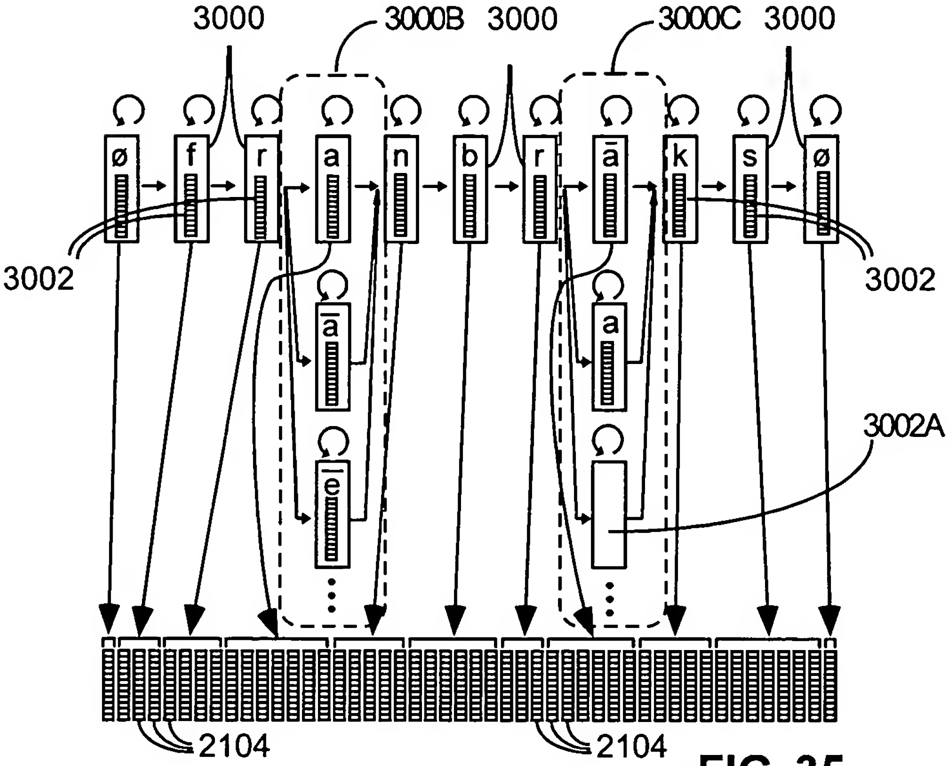

3000
3000B
3000
3000C
3000
ø
f
r
a
n
b
r
ā
k
s
ø
ā
a
ē
3002
3002
3002A
2104
2104

FIG. 35

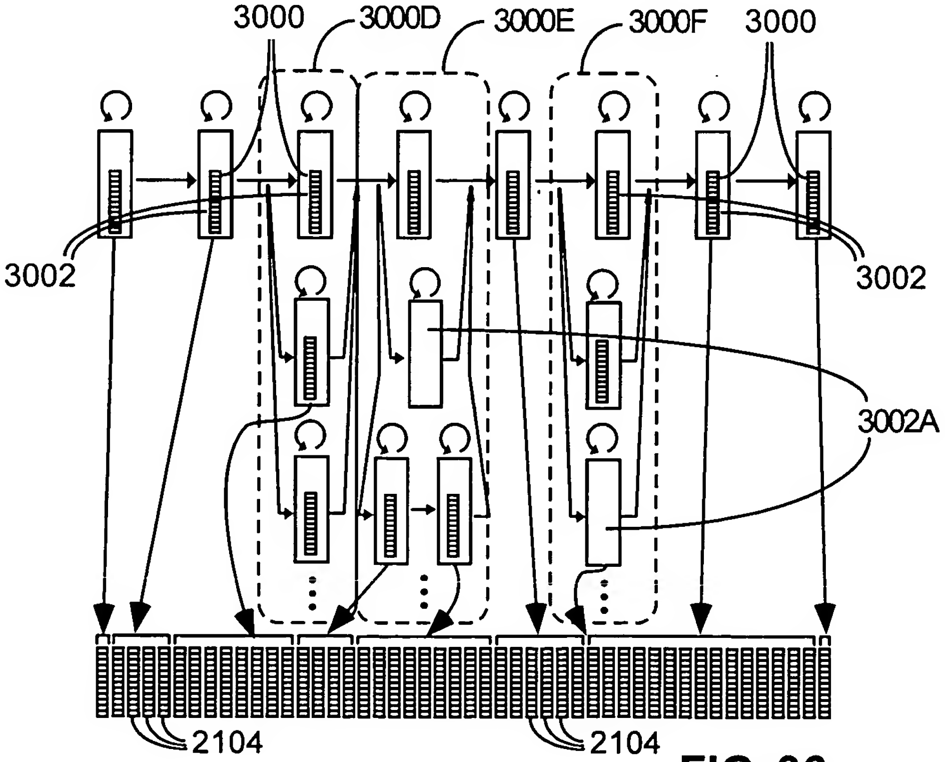

3000
3000D
3000E
3000F
3000
3002
3002
3002A
2104
2104

FIG. 36